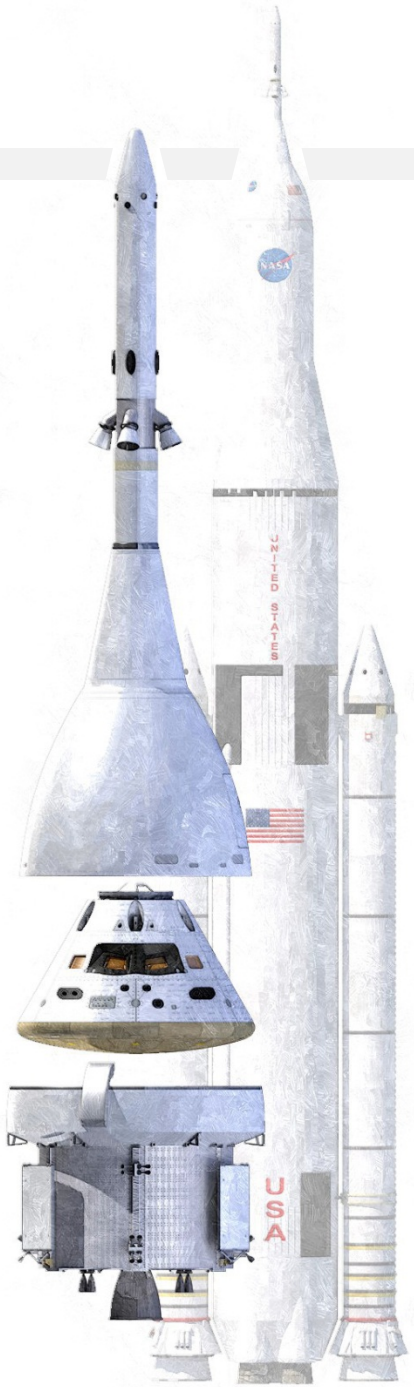


Building a Database for a Quantitative Model

May 9, 2014

… For a Quantitative Model

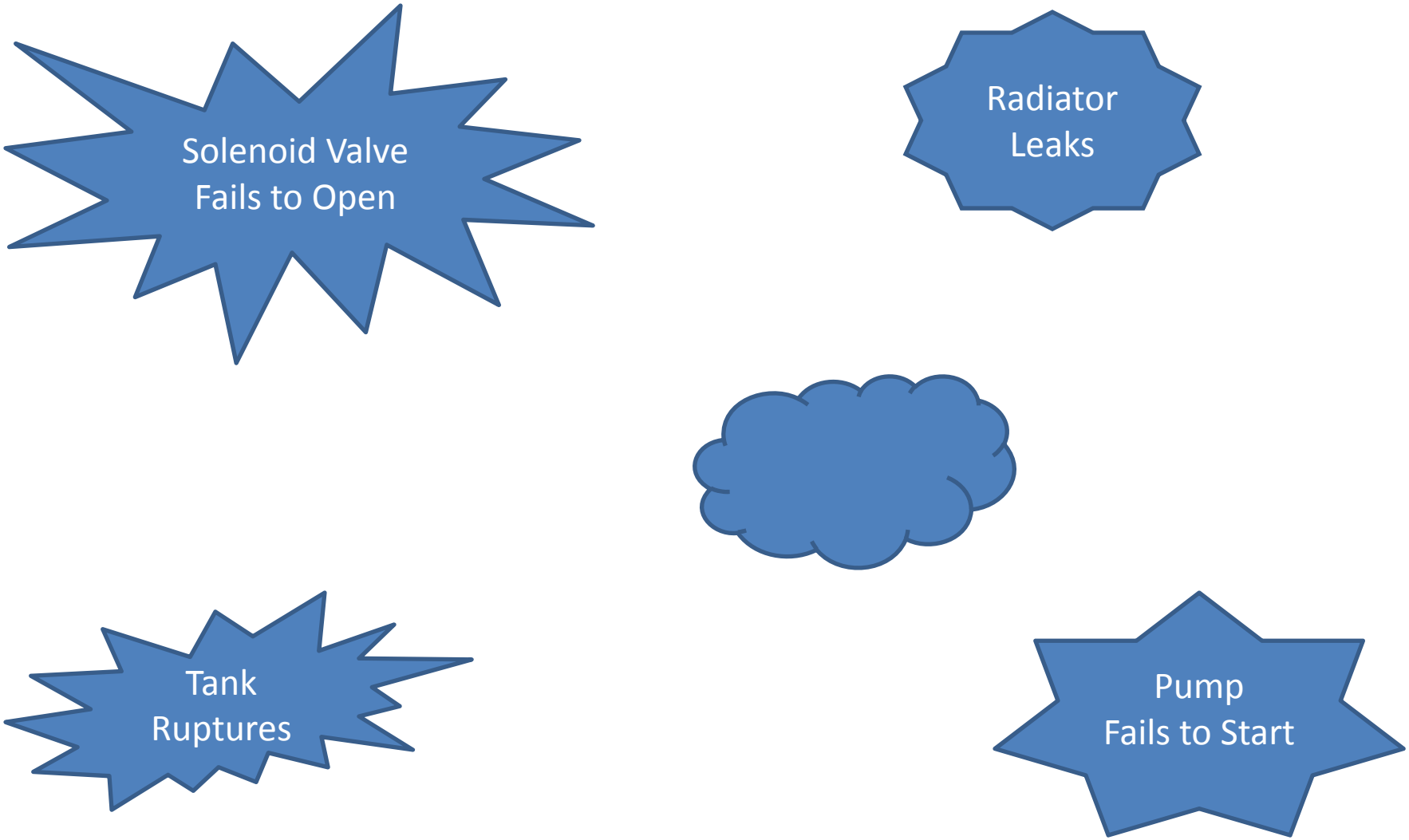
- The defining characteristic of a quantitative risk (or reliability) model is the use of failure estimate data.

- The credibility for the entire model often rests on the credibility and traceability of the data
  - The documentation is as important as the analysis

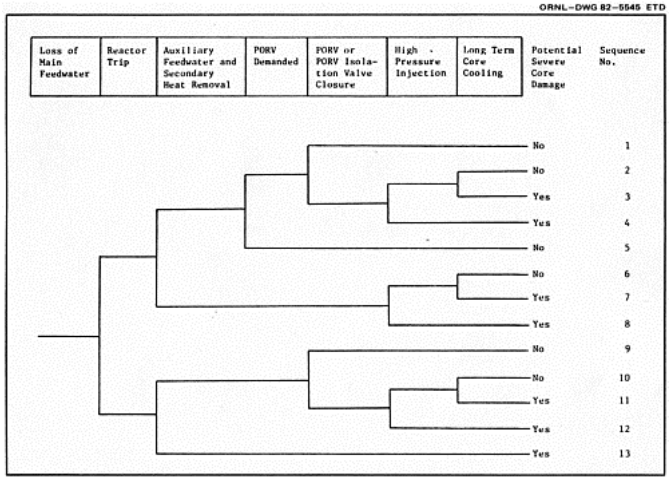
Building a database

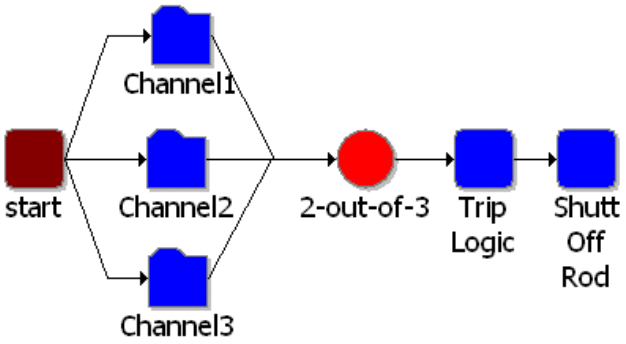
- A database can greatly benefit a quantitative analysis
  - Models can contain > 1,000 “Basic Events”
  - Data from 100+ individual calculations
- A database in Excel is sufficient
  - Link “Basic Events” to data sources

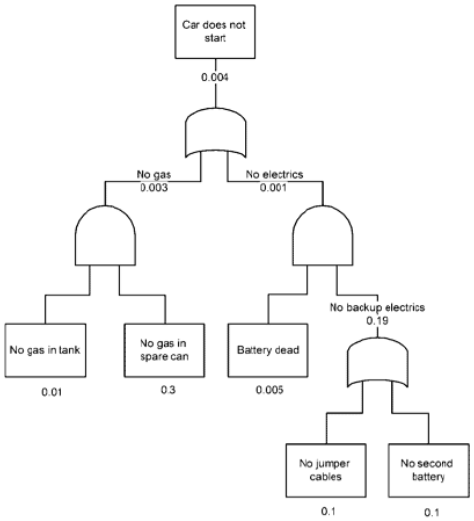
Failure Data Examples

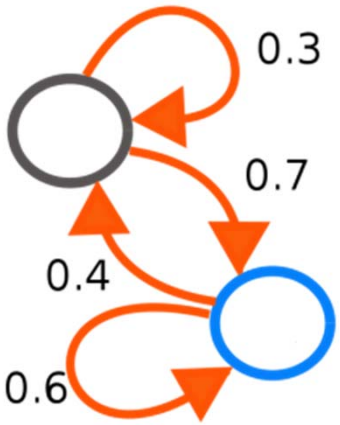


Modeled “Basic Events”







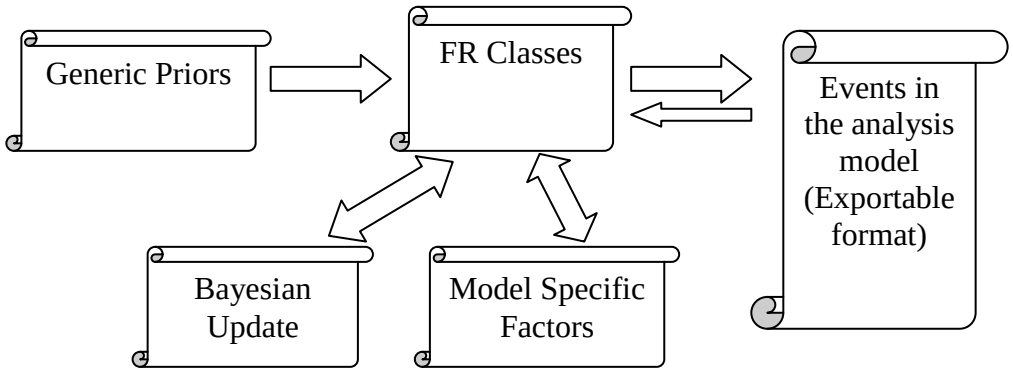


Database for a Model

- The database documents basic event
  - Failure probabilities
  - Failure rates and the mission time during which a failure could occur.

- The basic event failure rates and probabilities consist of a mixture of
  - Generic prior
  - Bayesian-updated posterior
  - Other recorded estimates
    - Offline evaluations that are inserted as basic events
    - Basic events that are developed using expert elicitation and engineering judgment .

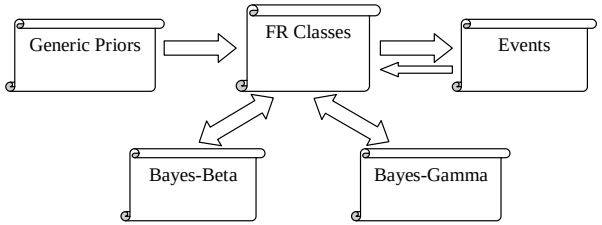
- The database file is organized by Correlation Class



Bayesian-Update Calculation, Example

FR Classes

	A	B	C	D	E	F	G	H	I	J	K	L
1	Component	Failure Mode	Description	Sample BE	Used	Index	Type	Dist	Mean	EF	Alpha	Beta
200	VLG-Gas-Gen	Opened	Gas regulator, fails open (High)	E_O_OSS_REG1_FHI	2	reg_120	Rate	L	7.23E-06	8.1	2.47E-01	3.42E+04
201	VLG-Gas^MPS	Opened	Gas regulator, fails open (High)	A_O_MPS_RGL1_FO	15	reg_120m	Rate	G	4.11E-05	3.2	1.56E+00	3.79E+04
202												



Weighted average of Means and Variances are Used to calculate Posterior Mean and Variance, which are used to calculate other parameters

Bayes-Gamma

	A	B	H	I	J	K	L	M	N	O	P	T	U	V
1	LOG NORMAL-GAMMA UPDATING													
2		Prior Parameters						Posterior Parameters						
3	Run		Gamma Parameters		Observations		Applicability Probability	Gamma Parameters				Log Normal Parmeters		
4	Identifier Index	Component Identifier	Alpha	Beta	Test Time	Failure Number	Gamma	Alpha	Beta	Mean	Variance	Error Factor	5% Bound	95% Bound
347														
348	reg_120m	VLG-Gas^MPS	2.47E-01	3.42E+04	10699			1.560203	37936.43	**4.11E-05**	1.08E-09	3.18	1.01E-05	1.02E-04
349						422	1							
350						923	0.5	Brazing procedures changed						
351						191	0.1	redesign to eliminating this failure cause						
352							u 0	2.47E-01	4.49E+04	5.51E-06	1.23E-10			
353							1 0.45	1.25E+00	4.49E+04	2.78E-05	6.18E-10			
354							2 0.5	2.25E+00	4.49E+04	5.00E-05	1.11E-09			
355							3 0.05	3.25E+00	4.49E+04	7.23E-05	1.61E-09			
356														

Each number from 0 to n is assumed

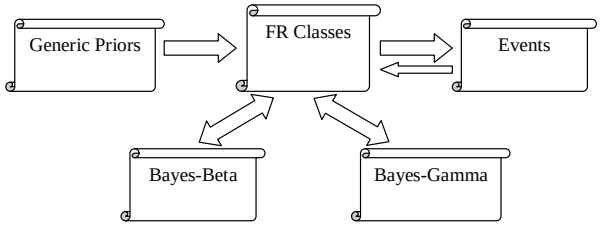
Alpha & Beta are calculated from failures and test time

Mean & Variance are calculated from Alpha & Beta

Database Example

FR Classes

	A	B	C	D	E	F	G	H	I	J	K	L
1	Component	Failure Mode	Description	Sample BE	Used	Index	Type	Dist	Mean	EF	Alpha	Beta
200	VLG-Gas-Gen	Opened	Gas regulator, fails open (High)	E_O_OSS_REG1_FHI	2	reg_120	Rate	L	7.23E-06	8.1	2.47E-01	3.42E+04
201	VLG-Gas^MPS	Opened	Gas regulator, fails open (High)	A_O_MPS_RGL1_FO	15	reg_120m	Rate	G	4.11E-05	3.2	1.56E+00	3.79E+04
202												



Weighted average of Means and Variances are Used to calculate Posterior Mean and Variance, which are used to calculate other parameters

Model Events

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	System	Top 99%	Index No	IMPS = * BE Name	FdT	UdC	Jd	UdValue	Prob	Lambda	Tau	Mission	Cat	PF	UdValue2
2						OV-						306,			
1920	mps	0	reg_120m	A_O_MPS_RGL1_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1921	mps	0	reg_120m	A_O_MPS_RGL2_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1922	mps	0	reg_120m	A_O_MPS_RGL3_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1923	mps	0	reg_120m	A_O_MPS_RGL7_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1924	mps	0	reg_120m	A_O_MPS_RGL8_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1925	mps	0	reg_120m	A_O_MPS_RGL9_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1926	mps	0	reg_120m	E_O_MPS_RGL1_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1927	mps	0	reg_120m	E_O_MPS_RGL2_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1928	mps	0	reg_120m	E_O_MPS_RGL3_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1929	mps	0	reg_120m	E_O_MPS_RGL7_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1930	mps	0	reg_120m	E_O_MPS_RGL8_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1931	mps	0	reg_120m	E_O_MPS_RGL9_FO	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----
1932	eclss	0	reg_120	E_O_OSS_REG1_FHI	3	OV-reg_120	L	8.10E+00	------E----	7.23E-06	0	1.17E+00			------E----
1933	eclss	0	reg_120	E_O_OSS_REG2_FHI	3	OV-reg_120	L	8.10E+00	------E----	7.23E-06	0	1.17E+00			------E----
1934	mps	0	reg_120m	A_O_MPS_PNEREG_FTR	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1935	mps	0	reg_120m	A_O_MPS_REGVPX_FHI	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	2.50E-01			------E----
1936	mps	0	reg_120m	E_O_MPS_PNEREG_FTR	3	OV-reg_120m	G	1.56E+00	------E----	4.11E-05	0	4.30E-01			------E----

What’s in Your Model?

Checking Data without a Database

- Check “Risk Drivers”
  - Requires most of the effort in building a database
  - Misses data entered Too Low
- Spot Check
- Just Assume correct data entry

Additional Benefits

- Sensitivity Studies
  - Changing “Class” data updates all related events
- Aids in Documenting Data
  - Database contains more information about data

Document data during development!

- If you don’t have time to do it right, when will you have time to do it over?
  – John Wooden